Identification	**Subject**	CHE 313, Heat and Mass Transfer 6 ECTS
	Department	Chemistry and Chemical Engineering
	Program	Undergraduate
	Term	Fall 2023
	Instructor	Rasoul Moradi
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	Phone:	
	Hours /Class	Wednesday 13:40-15:10 /115O, Friday 13:10-15:10 /414O
	Office hours	Tuesday, Wednesday, 17:00 – 18:00
Prerequisites	MATH 312-Differential Equation and Thermodynamics	
Language	English	
Compulsory/Elective	Compulsory	
Required textbooks and course materials	***Main textbook: (References)*** 1. Holman, J.P., "Heat Tansfer", 9th edn. The McGraw-Hill Companies, 2008. 2. McCabe, W. L., Smith, J. C., and Harriott, P., "Unit Operations of Chemical Engineering", McGraw-Hill, 6th. Ed., 2001 3. Chapman, A.J. "Heat Transfer", 4th edn. Maxwell Macmillan International Edition, 1984. 4. Bird, R.B., Stewart, W.E., Lightfoot, E.N. Transport Phenomena, 2nd ed. John Wile & Sons, New York (1999). ISBN 0-47011-539-4 5. Treybal, R. Mass Transfer Operations,3rd ed. McGraw Hill Chemical Engineering Series (1980) ISBN 0-07-066615-6. 6. Incropera, F.P., DeWitt, D.P. Fundamentals of Heat and Mass Transfer, 5th ed. John Wiley, Hoboken, NJ (2007). ISBN 0-47145-728-0. Supplementary material: 1. Class Lecture Handouts and Additional Reading Materials ***Supplementary material:*** Class Lecture Handouts and Additional Reading Materials	
Course outline	This course is the required for 3'th-year undergraduate students in the Khazar university chemical engineering program. The course content focuses on the fundamentals of diffusion and mass transfer in fluid (gas and liquid) systems. About two-thirds of the course emphasizes diffusion, while the remainder of the course emphasizes convective mass transfer. Major lecture topics are detailed in the Lecture Outline (see below). Students are expected to have completed some undergraduate coursework in the transport phenomena, including fluid flow (necessary) and heat transfer (desired). General Outline of Topics Covered: ➢ Heat Transfer Principals ➢ Heat Transfer Types ➢ Convective Heat Transfer: One dimensional ➢ Convection Mechanisms ➢ Heat Transfer in Boiling and Condensation ➢ Heat Transfer Coefficients ➢ Heat Exchangers and Fins ➢ Temperature Profiles	

	➢ Evaporators ➢ Mass Transfer Principals ➢ Molecular Diffusion ➢ Convective Mass Transfer ➢ Diffusion Coefficients ➢ Dimensionless Numbers ➢ Absorption ➢ Distillation
Course objectives	The main objective of the course is to teach the following general principles: General Principals of heat transfer by conduction, convection, radiation heat transfer. Conduction- Fourier's law of heat conduction, steady state conduction in one dimension without heat source e.g. Through plain wall, cylindrical & spherical surfaces, thermal insulations, properties of insulating materials. Convection- Natural & forced convection, concept of thermal boundary layer, laminar & turbulent flow heat transfer inside and outside tubes, dimensional analysis, determination of individual & overall heat transfer coefficients and their temperature dependency. Heat exchangers- Types of heat exchangers like double pipe, shell & tube, plate type, extended surface, their construction and operation, basic calculations on heat exchangers. Radiation- Basic laws of radiation heat transfer, black body & grey body concepts, view factor, combined heat transfer coefficients by convection and radiation. Mass transfer topics cover Diffusion in gases, liquids, solids, membranes, and between phases. Effects of reactions on mass transfer. Mass transfer rates by convection and dispersion. Rates of dispersion. Rates of combined heat and mass transfer.
Learning outcomes	At the completion of this course, the students will gain general knowledge about: ➢ Heat transfer by Conduction, Convention and Radiation ➢ Heat Exchanger: Classification; Construction of shell and tube heat exchanger ➢ Understand Basic concepts of transport phenomena ➢ Analyze mass transport phenomena in various phases ➢ Calculate concentration profiles in phases equilibria ➢ Calculate Multistage tray towers; Graphical methods using Mc Cabe-Thiele and Ponchon ➢ Multi component Calculations using Short-cut methods ➢ Analyze liquid-liquid and solid-liquid extraction operations ➢ Absorption operations and Adsorbents, adsorption equilibria ➢ computational modeling of mass transfer unit using ProMax, HYSYS and COMSOL

Teaching methods	**Lecture**		**x**
	Group discussion		**x**
	Experiential exercise		**x**
	Lab		**x**
Evaluation	**Methods**	**Date/deadlines**	**Percentage (%)**
	Midterm Exam		30
	Class Participation		10
	Quizzes		10
	Final Exam		50
	Total		100
Policy	▪ **Ethics** Use of any electronic devices is prohibited in the classroom. All devices should be turned off before entering class. This is a university policy and violators will be reprimanded accordingly. ▪ **Preparation for class** The structure of this course makes your individual study and preparation outside the class extremely important. The lecture material will focus on the major points introduced in the text. Reading the assigned chapters and having some familiarity with them before class will greatly assist your understanding of the lecture. After the lecture, you should study your notes and work relevant problems and cases from the end of the chapter and sample exam questions. ▪ **Class Parcipitation** For a variety of reasons, participation in a classroom context is essential. It is essential to the learning process, promotes teamwork, and aids in the general success of both the individual students and the class as a whole. 3 absence from class rub out 1 point. ▪ **Quiz** A consistent method of gauging your understanding of the content covered in class is through quizzes. They assist you and your teacher in evaluating your comprehension of important ideas and identifying any areas that can benefit from more explanation. The quiz is conducted in written form. Open-ended questions are worth 1 or 2 points depending on the level of difficulty. The quiz is evaluated with a total of 10 points. ▪ **Withdrawal (pass/fail)** This course strictly follows grading policy of the School of Science and Engineering. Thus, a student is normally expected to achieve a mark of at least 60% to pass. In case of failure, he/she will be required to repeat the course the following term or year. ▪ **Cheating/plagiarism** Cheating or other plagiarism during the Quizzes, Mid-term and Final Examinations will lead to paper cancellation. In this case, the student will automatically get zero (0), without any considerations. ▪ **Professional behavior guidelines** The students shall behave in the way to create favorable academic and professional environment during the class hours. Unauthorized discussions and unethical behavior are strictly prohibited.		

Tentative Schedule

Week	**Topics**	**Textbook/Assignments**
1	Introduction 1.1 Modes of heat transfer 1.1.1 Conduction 1.1.2 Convection 1.1.3 Radiation 1.2 Material properties of importance in heat transfer 1.2.2 Thermal conductivity	Chapter 1, Ref. 1

	1.2.2 Specific heat capacity	
1	Conduction: One Dimensional 2.1 Steady state conduction through constant area 2.2 Thermal contact resistance 2.3 Steady state heat conduction through a variable area 2.3.1 Cylinder 2.3.2 Sphere 2.4 Heat conduction in bodies with heat source	Chapter 1, Ref. 1&2 Quiz 1
2	Conduction: One Dimensional 2.1 Steady state conduction through constant area 2.2 Thermal contact resistance 2.3 Steady state heat conduction through a variable area 2.3.1 Cylinder 2.3.2 Sphere	Chapter 2, Ref. 1, Quiz 2
2	Conduction: One Dimensional 2.3.3 Heat conduction in bodies with heat sources	Chapter 2, Ref. 1
2	Convective Heat Transfer: One dimensional 3.1 Principle	Quiz 3
3	Convective Heat Transfer: One dimensional 3.2 Individual and overall heat transfer coefficient 3.2.1 Heat transfer between fluids separated by a flat solid wall	Chapter 3, Ref. 1
3	Convective Heat Transfer: One dimensional 3.2 Heat transfer between fluids separated by a cylindrical wall 3.3 Enhanced heat transfer: concept of fins 3.3.1 Analytical solution of different cases 3.3.2 Fin efficiency 3.4 Thermal insulation	Chapter 3, Ref. 1 Quiz 4
3	Forced Convective Heat Transfer 4.1 Principle of convection 4.2 Forced convection mechanism: Flow over a flat horizontal plate 4.3 Flow through a pipe or tube 4.3.1 Turbulent flow	Ref. 1&2
3	Forced Convective Heat Transfer 4.3.1 Turbulent flow 4.3.2 Laminar flow	Ref. 1&2 Quiz 5
4	Heat Transfer by Natural Convection 5.1 Introduction 5.2 Empirical correlations for natural-convective heat transfer 5.2.1 Natural convection around a flat vertical plate	Quiz.6
4	Heat Exchangers 6.1 Elements of shell and tube heat exchanger 6.2 Thermal design of heat exchangers 6.2.1 Overall heat transfer coefficient 6.2.2 Fouling factor or dirt factor 6.2.2 Temperature profiles in heat exchangers 6.2.4 Why multi-pass exchangers 6.2.5 LMTD correction factor	Reference 1&2 Quiz 7
4	Heat Exchangers 6.2.6 Individual heat transfer coefficient 6.2.7 Pressure drop in the heat exchanger 6.2.7.1 Correlation for tube side pressure drop 6.2.7.2 Correlation for shell side pressure drop	Reference 1&2 Quiz 8

	6.2.8 Heat transfer effectiveness and number of transfer units 6.2.9 Calculation and designing of the heat exchanger 6.2.9.1 Double-pipe heat exchanger 6.2.9.1 Shell and tube heat exchanger	
5	Radiation Heat Transfer 7.1 Basic definition pertaining to radiation 7.1.1 Emissive power 7.1.2 Radiosity 7.1.3 Irradiation 7.1.4 Absoptivity, reflectivity, and transmissivity	Reference 1 Quiz 9
5	Evaporators 8.1 Heat Transfer coefficient 8.2 Performance of steam heated tubular evaporators	Reference 1 Quiz 10
6	Heat transfer laboratory: 1 Counter current flow experiment	1 Reports

Week	Date	Topic	Reference
		Midterm Exam	
7	17.02.2023	Introduction to Mass Transfer 1.1 Terminology and semantics	Ref.4 Ref. 5 Ref. 1 Ref.4 Ref. 5
7	24.02.2023	Diffusivity and the mechanisms of mass transport Fick's law of binary diffusion Theory of diffusion in colloidal suspensions Theory of diffusion of polymers Mass and molar transport by convection Maxwell-Stefan equations for multicomponent diffusion in gases at low density	Ref.4 Ref. 5 Ref. 1 Ref. 2 Ref. 2 Quiz 11 Ref.4 Ref. 5
7	03.03.2023	Concentration distribution in solids Shell mass balances, boundary conditions Diffusion through a stagnant gas film	Ref.4 Ref. 5 Ref. 1, Ref. 2 Quiz 1 Quiz 12
8	10.03.2023	Diffusion with a heterogeneous chemical reaction Diffusion with a homogeneous chemical reaction	Ref. 1 Ref.4 Ref. 5
8	17.03.2023 30.03.2023	Temperature and pressure dependence of diffusivities Theory of diffusion in gases at low density Theory of diffusion in binary liquids	Ref. 1 Ref. 2 Quiz 2 Ref.4 Ref. 5
8	03.04.2023	Diffusion through a stagnant gas film Diffusion with a heterogeneous chemical reaction Diffusion with a homogeneous chemical reaction	Quiz13 Ref. 1 Ref. 2 Ref.4 Ref. 5
	11.04.2023	**Midterm Exam**	
9	18.04.2023	Equations of change for multicomponent systems 4.1. The equations of continuity for a multicomponent mixture	Ref.4 Ref. 5 Ref. 2 Quiz3
		4.2. Summary of multicomponent equations of change	Ref.4 Ref. 5
10	25.04.2023	4.2. Summary of multicomponent equations of change	Ref. 2 Ref. 4 Ref. 5 Quiz 14
10	01.05.2023	4.3. Summary of multicomponent fluxes 4.4. Use of the equation of change for mixtures 4.5. Dimensional analysis of the equations of change for binary mixtures	Ref. 2
		Distillation operations Adsorption operations	
11-13	08.05.2023 15.05.2023	Distillation operations	Ref.2 Ref. 2
	22.05.2023 29.05.2023	Adsorption operations Final Exam **Midterm Exam**	Ref. 3 Ref. 2 Quiz 4